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Diffusion of straw bale building in Norway and Denmark

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Abstract

Straw bale building is an environmentally friendly building technique that has not yet reached the broad masses of the population. In spite of world leaders and scientist being concerned with human impact on our environment and climate, and media coverage of issues related to sustainability, there has not been wide diffusion of this building style. Straw bale building makes use of the leftovers from grain production, has very good insulation properties, and has high carbon storage potential, making it a suitable solution to the environmental challenges of our time. This thesis seeks answers to why straw bale building has not diffused more, using Everett M. Rogers' renowned theory about diffusion of innovations. Qualitative research provides data about the attributes of this particular innovation, characteristics of early adopters of the innovation, as well as other aspects like communication channels and the social context, which could tell us something about why it has not become more popular. Perceptions and experiences about straw bale building in Norway and Denmark are examined through eight interviews with both straw bale builders and straw bale experts. A comparative analysis of Norway and Denmark is also provided. The main findings are that the straw bale building's complexity, time- and labour-intensiveness, and its connection to an alternative lifestyle, are factors that are hindering the innovation's diffusion. There is also a lack of information and knowledge about it in society. The thesis argues that if straw bale building is to become a viable option for a larger portion of the populations of Norway and Denmark, the reasonable way forward is its industrialization.

Keywords: Straw bale building, Diffusion of innovations, Sustainable building.

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I would like to thank the interviewees for finding the time to talk to me about straw bale building. Their willingness to share their experiences provided me with crucial insights into what obstacles may be obstructing the diffusion of straw bale building, and made the thesis "down-to-earth" and realistic. Ingrid and Fridrik Bertelsen, Tove and Anders Sanderhoff Sørensen, Ole Busck, Roar Lefsaker, Caroline Meyer White, Rolf Jacobsen, Piet Jensen and Steen Møller: Thank you, I am very grateful to you for your help.

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I would also like to thank the academic staff at the University of Oslo for giving me a solid foundation in the field during my first ESST semester, and for encouraging me to go abroad for my second semester.

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"I'll huff, and I'll puff, and I'll blow your house in!"

From the traditional fairy tale "The three little pigs"

Straw bale house at Friland, Djursland, Denmark.

Photo: Agnese Bremere

1.1 A house of straw

When people hear of a house made of straw they might think of the house of the first piglet in the fairy tale of the three little pigs and the wolf. That image would not be of a sturdy house built to last, considering that the wolf blew the house down. But modern straw bale building is far from fable. It is a reality some untraditional builders have made for themselves and continue to live in.

A straw bale house is a house that uses the by-product of grain production as a building material. The straw is compressed into bales and used as building blocks, much like large bricks, for structures of all kinds. The bales can be the load-bearing element of the structure, with the roof resting on top of the thick walls, or they can be used as walls between load-bearing timber frames, with no support function. There are also hybrid versions of these two types where both a frame and the bales carry the load.

The walls are coated with several layers of plaster, most commonly clay or lime, which protects the straw from moisture and keeps it from decomposing, as well as keeps mice and bugs out of the walls. The interior of a straw bale house can be as different or similar to traditional interiors as one chooses, but the main characteristics are deep windowsills and soft edges around corners, giving the house an “organic” look.

Building with straw bales offers several significant advantages. The materials are natural and degradable; they do not emit any toxic gases and can be discarded after use without leaving any residue that can be harmful to the environment.

The materials are cheap and can be found wherever there is grain, which is a crop cultivated in many different countries and climates, thereby leaving out transportation costs, which further reduces the carbon footprint of the materials. Instead of straw being dug back into the soil or burnt, it can serve as a cheap and easily accessible building material.

Straw bale walls are able to breathe, meaning that the moisture content inside the house regulates itself naturally. This provides an exceptionally good climate inside the house without a complicated ventilation system.

Last but not least, straw bales have excellent insulation properties, which make straw bale buildings a viable choice when energy-efficiency is considered.

1.2 A world in crisis

Reduced energy consumption is a property to strive for, both for the individual house builder and the planet as a whole. The Intergovernmental panel on climate change says in its Fifth Assessment Report (AR5) from 2013 that it is 95 per cent certain that human activity is responsible for climate change in the last fifty years, where the atmosphere and oceans have warmed, snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased. Continuing greenhouse gas emissions at current or higher levels are likely to have detrimental effects on our planet, like loss of species and an increase in extreme weather events. (IPPC, 2013)

Sufficiently reducing carbon gas emissions has proven to be a tough job. Even though world leaders agreed to extend the Kyoto protocol for cuts in greenhouse gas emissions towards 2020, at the 2012 Doha Climate Change Conference, the Norwegian Minister for the Environment said, "It is an important agreement, but we have not yet the agreement that we really need."[1]

Politicians and scientists are looking for other ways to reduce carbon dioxide from the atmosphere, through for instance carbon capture and storage, and reforestation. Straw bale building can contribute to this effort. As we will see further on in this paper, scientists think straw bale walls have great capacity for carbon storage.

[1] http://www.nrk.no/nyheter/klima/1.10123901

1.3 Research objective

Considering all the outstanding advantages of using straw as a building material, it is puzzling that there are not more straw bale buildings. In Norway there are some seventy buildings, including livestock housing and barns. In Denmark the number is far higher. Although no one keeps count, Denmark has approximately a thousand small and large straw bale buildings.

My objective is to find out why straw bale building is not a more popular building method, using Everett M. Rogers' Diffusion of Innovations approach. I also want to find out what characterizes the people that have chosen the untraditional route and built a house of straw. I will also compare and contrast straw bale building in Norway and Denmark. Even though these two Nordic neighbours are in many respects similar, I suspect that there might be a mutual opportunity for learning between these two countries when it comes to straw bale building. Norway and Denmark are also the two countries I am most familiar with; being from Norway and studying in Denmark has given me insights in straw bale building in both countries, and an opportunity to highlight the differences I came across.

Other research that I have found similar to my own undertaking is a paper by White et al. that conducted a survey of participants from Denmark and North America, which sought to investigate perceived barriers to straw bale building and develop a design guide to help potential builders overcome some uncertainties in the construction. In their research they found that the main barrier to straw bale building is the lack of standardized materials and methods, too many variables for the traditionally trained craftsman, as well as the lack of accessibility to skilled labour, and general knowledge and inaccurate perceptions about straw bale building. (White et al., 2012)

My research differs from White et al.'s in that it deals with straw bale building in Norway and Denmark and uses Roger's theory Diffusions of Innovations as a tool to investigate the diffusion process. I have not come across any other studies that couple straw bale building with a theory of diffusion, and I see this as my contribution to new knowledge about straw bale building. Furthermore, my thesis also discusses the characteristics of early adopters of straw bale building, an effort I have not seen in other research.

1.4 Field of study

The ESST-field of study provides the student with tools to better understand the complex processes of innovation and technological change. It offers a new way of looking at things that we take for granted in every day life, whether it is about how innovations occur, or how new technology affects the world around us.

I chose the diffusion-approach because I wanted to find out why people are not tapping into a readily available building material that offers solutions to problems in traditional buildings, like high energy-consumption, use of scarce resources, toxic chemicals, energy-intensive production processes, and less-than-healthy indoor environments.

Everett M. Rogers is considered having written the most comprehensive guide of how to study diffusion of innovations. His approach highlights the underlying reasons for an innovation's success, or the lack of it. I hope my thesis can contribute to a better understanding of the reasons behind people's choices and provide clues for policy makers, interest organizations or activists that can help change the status quo.

This thesis provides new insight in how the new technology of straw bale building has trouble in breaking ground among more established technologies, how problems related to climate change and sustainability calls for new solutions, and how previously less discussed issues, like indoor climate, makes people chose alternative building materials.

In the following I describe what a straw bale house is, the history behind it, and what advantages and disadvantages it may have. After that is a methodology section where I argue for why I have chosen the qualitative interview as my method to gather empirical data, and a description of the interview-process. Then I describe the origins of the Diffusion of Innovations approach and outline the main aspects of it. In the main section, I present the interviews and the analysis on the background of the different parts of Roger's theory, before presenting a comparative analysis of the findings in Norway and Denmark.

2. Straw bale building

"Three things are to be looked to in a building:
That it stand on the right spot; that it be securely founded;
That it be successfully executed."
Johann Wolfgang von Goethe in 'Elective Affinities' (1809)

Straw bale house at Friland, Djursland, Denmark.

Photo: Agnese Bremere

2.1 History

Throughout the ages humans have gathered all sorts of materials to build shelter from the elements. Straw is one of these materials. Since the Palaeolithic Era there have been built straw huts on the African plains. Straw-thatched roofs have for centuries been common in many countries of Northern Europe and Asia. Cob, an ancient building material of mixed clay, straw, sand and water, has been used in a variety of locations around the globe. Overall, we can say that straw as a building material has been around for a very long time. However, it is only in recent years it has been rediscovered and combined with modern building techniques to provide modern houses suitable for the 21st century.

Straw bale building was made possible by the invention of mechanical hay balers. A bale is a bundle of straw tightly bound together with twine or wire, in a square, rectangular or round shape. Hand-operated presses appeared in the USA around 1850, before a stationary horse-powered baler took over by 1872. By about 1884, steam-powered balers were available, but the horse-powered baler was in use at least until the 1920s. (Myhrman & MacDonald, 1997)

The first documented examples of straw bales being used in permanent dwellings are found in the Sand Hills region of Nebraska, USA, from around 1900. The cost of available timber due to the lack of it, as well as limitations by the sandy ground, made homesteaders choose the readily available straw from the prairie as building material for their homes. (Lacinski & Bergeron, 2000)

Many of these first houses have survived to this day, serving as examples of straw bales' durability. However, towards mid-19th century, straw bale building faded away because it was replaced with more advanced building techniques.

> *"The technique may have died out completely, were it not for an article by Roger Welsh in 'Shelter', a compendium of indigenous and off-beat building styles from around the world, written for a 1970s back-to-the-land audience." (Lacinski & Bergeron 2000, p. 16)*

Roger Welsh's article from 1973 inspired enthusiasts around the world to start experimenting with the technique, and a straw bale revival was set in motion. People were building straw bale homes and writing handbooks about the process, which in turn inspired others to do the same. Different methods were tried and tested, people were, so to speak, learning while they were building.

As years went by, the pioneers organized and founded Out on Bale, a resource centre for straw bale building. In 1993 the magazine *The Last Straw* was issued to spread knowledge about straw bale projects and experiences. At universities, researchers tested insulation capacity, structural load properties and fire resistance of straw bale walls.

Today, straw bale building has spread to many countries and climates. In England, Germany, USA, Canada, Australia, Pakistan, China, and the Nordic countries, straw bale homes are appearing, though at a slow pace.

As of January 1 2012, there are 81 straw bale buildings in Norway, according to the Norwegian earth and straw building union (NJH). Of these 32 are residential houses. The rest include livestock housing, barns, ateliers and outhouses, in addition to demonstration buildings and some commercial buildings. There is even a straw bale kindergarten at Skollenborg in Buskerud.

Building engineer Caroline Mayer White, who's studies were focused on straw bale building, says there are no official records of Danish straw bale houses, but that she estimates that in 2004 there were about a thousand of all kinds of straw bale houses. (18.06.13) The number today must be well over a thousand.

The best-known Danish straw bale houses may be those at Friland in Djursland. 12 families built their straw bale homes followed by thousands of viewers through a television programme by Danish Radio. Today, Friland is expanding, as more and more people want to join the community and build their own straw bale homes.

2.2 The building process

This paper does not include all the technical details of how to build a straw bale house, since that would be too comprehensive a task. There are many handbooks on the topic for those interested in the step-by-step process. However, I would like to give the reader some idea of how a straw bale house is constructed.

The first step of building a house is laying a foundation. In this regard, a straw bale house is no different than any other house. It is the next step that is fundamentally different from traditional building. One does not go to the building store to buy ready-made materials, one has to ask a farmer if he has any straw bales left over from the grain harvest, and if they are pressed tightly enough for building purposes. This is not a straightforward process, considering that the harvest might be bad that year, the farmer might live far away, or he intends to use the straw as animal feed, or for some other purpose.

Providing one has enough straw bales to construct a house, there is the challenge of keeping them dry. There is a moisture protecting membrane between the foundation and the straw bale walls, but before they are put into place at the building site, they must be stored under some kind of roof. They must also be protected from moisture during the building process.

In houses with a load-bearing timber frame, the roof can be lifted into place before the walls are built, thereby protecting them during construction. In load-bearing houses, however, one has to cover the walls at all times in case of rain during construction. This can be a cumbersome task if the wind is not on your side.

The bales are stacked like bricks on top of each other and pierced with long sticks of wood, bamboo or rebar, to keep them stable. In places where extra fortifications are needed, like around windows and doors, a net is "sewn" on with wire. Moisture protecting membranes can also be installed on exposed walls.

The walls are coated with several layers of a plaster of choice, like clay or lime, both inside and out. The roof and floors can also be insulated with straw, or some other environmentally friendly material, like wood chips or mussel shells.

Each builder has of course his or her own method of how to build a straw bale house, and there are many different approaches and solutions. Therefore, this description is just meant as an illustration of how a straw bale house could be constructed.

2.3 Considerations

2.3.1 Design

There are some considerations to be taken into account when building with straw bales. If a framework carries the weight of the roof, the limitations in design are very few; one could build a multi-story building with straw bale infill, or "wrap" a large building in straw bales. However, if the walls are to be load bearing, the unique properties of bales and bale walls must be considered.

> *"Historic experience and structural testing suggest reasonable limits on the following: 1) the maximum height of walls; 2) the maximum length of wall between buttresses or braces; 3) the individual position and width of, and the total area of, the openings in*

any one wall, and 4) the maximum compressive load on any square foot of wall-top area." (Myhrman & MacDonald, 1997, p. 11)

It is important to consider the best design for solar heat gain to further increase the energy-efficiency of the house. Such design features can be large south-facing windows, integrated solar panels and heating systems, or simply a smaller building that utilizes the living area better.

Different ways to protect the house from moisture also has an effect on the design, like for example roof overhangs. Deep windowsills and possible roof overhangs affect the amount of daylight that is able to penetrate the house, meaning it must be taken into consideration in the building's design. There is a possibility to colour the natural plaster of the walls, but natural and degradable paints must preferably be used, which influences the colour selection.

2.3.2 Moisture

Moisture is a concern in straw bale construction like it is in standard wood-frame construction. Thick and well-insulated walls make it difficult for any moisture that enters the wall system to escape. Measures must therefore be taken to prevent this from happening.

A report from Danish Building and Urban Research shows that even when exposed to a simulated Danish winter, the tested straw bale walls stayed below the level of moisture content where rot and mould would be a concern. (Munch-Andersen & Andersen, 2004)

Goodhew et al. shows in their research that seven of the eight monitored sensors in the case study straw bale building had moisture levels below 20 %, which is below the level associated

with the start of degradation of the straw. However, one sensor placed in one severely exposed wall did record moisture contents of 25% for a period of several months. (Goodhew et al., 2004)

This shows just how crucial proper design and protection from moisture is in straw bale buildings. A soundly designed straw bale house need not have more problems with moisture than a traditional house, but this vulnerability must be taken into account in the design. One strategy in wet climates includes using lime plaster instead of clay, which handles rain a bit better. Another is simply installing wooden panels over the straw bale wall, with some space for ventilation, to protect it from rain.

2.3.3 Fire

Another issue that may come to mind for people first hearing of a straw bale home is whether or not it is a fire hazard. Field and laboratory tests show that plastered bale walls are highly resistant to fire damage, flame spread and combustion. (Theis, 2003)

Danish Building and Urban Research found that the straw bale walls and the plaster they tested easily fulfilled Danish fire codes for small houses. (Munch-Andersen & Møller-Andersen, 2004, p. 21)

It is reasonable to argue that straw bale homes do not easily burn; the plaster is thick and the compressed straw bales do not leave much oxygen to enable the walls to catch fire. Loose straw on a building site, however, is an entirely different matter, and must be adequately protected or removed from the building site.

2.3.4 Pests

A common thought that crosses people's minds are also that there might be mice in the walls of a straw bale house. Fact is, it is not any more likely to have mice in a straw bale house than it is to have them in a wooden house, or any other house, if it is not properly sealed. The plaster on the straw bales is thick enough to prevent any pests from chewing through it, and there is little room inside the bales for mice and bugs. The important thing to consider is to prevent any gaps or openings that could invite the little creatures in, install a wire net in places where they could try to get in, or adding lime to clay plaster making an alkaline environment unfavourable to bugs. (Jacobsen, 2009, p. 36)

2.4 Advantages

"Houses are built to live in and not to look on;
Therefore let use be preferred before uniformity,
Except where both may be had."
Francis Bacon in 'Essays' (1625) 'Of Building'

Detail from a straw bale house at Friland, Djursland, Denmark.

Photo: Agnese Bremere

2.4.1 Insulation and energy efficiency

U-value is a measurement of heat loss in a building element, for example the walls or roof. High U-values mean that the thermal performance of the building is below par, while a low U-value usually indicates a high level of insulation.

The report from Danish Building and Urban Research shows that straw bale walls comply with the U-value demands for lightweight outer walls as prescribed by Danish building authorities. (Munch-Andersen & Møller-Andersen, 2004)

The insulation properties of straw bale walls naturally depend on the thickness of the straw bales, but U-values for straw bales usually fall between 0.13 and 0.19 and high levels of air-tightness can be achieved. (White, 2013)

The direction in which the straw lays also has an effect on its insulation properties; stacking the straw bales with the length of the straw vertically gives better insulation than horizontally laid straw bales. (Jacobsen, 2009, p. 25)

2.4.2 Carbon storage

Straw has a positive "carbon footprint", which means that there is more carbon dioxide stored in the plants than what is emitted through planting, harvesting, baling and building with straw.

A British study of the role of straw bale construction as a means for reducing the whole-life impact of housing, estimate that the total emissions of building elements per house was thirteen tonnes of CO2, without sequestration.

"By considering the carbon lock-up potential of straw, wood and wood products, each dwelling may be considered as a carbon sink negating the impacts of non-renewable materials resulting in locking up around 7 tonnes of CO2." (Sodogar et al., 2011)

The researchers found that the renewable construction materials reduced the case study house's whole-life CO2 emissions by 61% when compared to the case without sequestration.

Similarly, a Finnish study about carbon storage in biochar and straw bale construction from a life cycle perspective concludes:

"Straw bale construction is a relatively low-tech method for carbon storage, which has a high potential for offsetting residential greenhouse gases. Therefore the technology should be included when considering climate mitigation scenarios." (Mattila et al., 2012)

Although, the scientists found that the majority of emission savings was due to avoided energy production provided by the high degree of insulation compared to traditional housing, there is a potential for extra carbon storage in straw bale houses. Compared to a passive house, which also significantly cuts energy consumption, one should consider if not the straw bale house is a more suitable alternative if the goal is carbon storage.

2.4.3 Indoor climate and air quality

Volatile organic compounds (VOCs) are gases that are emitted from certain solids or liquids. They include a variety of chemicals, some of which may have short- and long-term adverse health effects. “Concentrations of many VOCs are consistently higher indoors (up to ten times higher) than outdoors” (EPA, 2013)

Many products, like paints, cleaning supplies, pesticides, building materials and furnishings, and many more, emit VOCs. Thousands of synthetic chemicals have been incorporated into building materials, and building envelopes are sealed so tightly that chemicals and occupant-generated pollutants remain trapped inside homes, where they are inhaled into the lungs and absorbed through the skin. (Baker-Laporte et al., 2008, p. 1)

Using natural materials when building, as is done in many straw bale houses as far as practically feasible, and building a vapour diffusible and breathing building, offer the significant advantage of avoiding many of these gases that may cause adverse health issues.

2.4.4 Economy

Straw bales and plaster are inexpensive compared to other building materials, but considering that the walls of the building are usually 10 to 20 per cent of the overall cost of the house, the potential savings can be insignificant. Rather, the projected savings from lower electricity bills and maintenance costs are more important.

The self-builder also saves a lot of money by doing the labour him-/herself. The overall cost also depends on the design of the building. The simple load bearing style of the pioneer examples is less costly, regarding material costs, than a house with load bearing timber walls.

2.4.5 Ecology

Straw is a bi-product of agriculture, is available in abundance, and is a sustainable resource. An average straw bale house would use around 150 cubic metres, or 15 tonnes, of straw, which is a very small amount of the straw available. (Munch-Andersen & Andersen, 2004, p. 39)

There are no significant environmental impacts associated with the production of straw bale walls. The only environmental impact is the transportation from field to construction site. The total environmental impact would thus be significantly lower than for traditional external walls.

As mentioned in the introduction to this thesis, our world faces great challenges when it comes to our use of resources. A building mentality where the focus is on sustainable materials and energy-efficiency could offer good solution to these challenges. The issue is, though, to get more people to use alternative building methods, because in battling environmental issues, strength is in numbers.

3. Methodology

3.1 Qualitative research

The purpose of this research was to map obstacles in straw bale building, and to find out what characterizes straw bale builders; both aspects should provide some understanding of the reasons behind the slow diffusion of straw bale building.

Qualitative research means studying spoken and written records of human experience and there are different ways of collecting qualitative data, the main being the interview, observation, participant observation and documents. (Punch, 2005, p. 168)

I chose the interview as my method of data gathering because it is an excellent way to gain insight into people's perceptions and interpretations of reality. It was in my opinion the best way to come as close as possible to the people and the opinions I wanted to study. I have also relied on desk research, which consists of gathering information already available in print or published on the Internet. Books about straw bale building and research papers and reports about issues connected to sustainability have been useful.

3.2 The interviewees

The interviewees were builders and owners of residential straw bale houses. In order to understand what could inhibit the diffusion of straw bale houses I wanted to interview those who had gone through the whole building process, and learn about their experiences. Also, I consider these people to be among "early adopters" and wanted to find out what

characteristics they have, to see if they somehow set themselves apart from mainstream society.

I also interviewed people I categorized as experts. These persons have worked with straw bale building or design for many years and would have a good overview and in-depth knowledge of the developments and current status of this kind of building.

The expert-interviewees were:

Rolf Jacobsen, architect in Gaia Architects in Norway. He has designed or been involved in the construction of the majority of Norwegian straw bale houses. Gaia Architects is one of the most sustainability oriented architectural firms in Norway.

Piet Jensen, contractor and carpenter. He is one of the few constructors of straw bale houses in Norway, and has been involved in the building of very many Norwegian straw bale houses.

Caroline Meyer White, a constructional engineer living in a straw bale house at Friland, Denmark. She wrote her diploma thesis about straw bale building, has built several straw bale houses, and is actively engaged in the promotion of straw bale building. As far as she knows, she is the only engineer working with straw bale building in Denmark.

Steen Møller, one of the most prominent figures of straw bale building in Denmark. He was involved in Danish Radio's TV-programme about Friland, has built several straw bale houses, and holds workshops in straw bale building in Denmark. He has partnered with among others Caroline Meyer White to start production of ready-made straw bale building elements.

The other group consists of the builders, those who made a choice to build a straw bale house for themselves. I wished to find out why they chose the non-traditional path and hear about their experiences. The builders were:

Fridrik and Ingrid Bertelsen, who have had a straw bale house built at Nesodden, just outside Oslo, Norway. They outsourced the building of the whole house, and their house serves as an example that a straw bale house is also an option for non-self-builders.

Tove and Anders Sanderhoff Sørensen, from Skien in Telemark, are currently building their straw bale house. They are mostly self-builders.

Ole Busck. He built a straw bale house outside of Aalborg, Denmark, from 2003 to 2005. He does not live in his straw bale house anymore.

Roar Lefsaker from Våle in Vestfold, Norway. He participated in the building of several straw bale houses at Holt farm.

More information about the interviewees can be found in Appendix A.

I found the interviewees mainly through desk studies, particularly by searching the Internet for web sites and articles about straw bale building. There were also some interviewees that I came in contact with through a snow-baling effect, meaning that when one talks to one person, he or she can point you further to other relevant persons to talk to.

I found the Norwegian interviewees, Rolf Jacobsen, Piet Jensen, Tove and Anders Sanderhoff Sørensen, and Ingrid and Fridrik Bertelsen through the NJH-website. I came in contact with Roar Lefsaker through e-mail correspondence with Holt farm in Vestfold, which I read about on the NJH-website. The Danish interviewees were found through several sources. I heard about Ole Busck from my supervisor Birgitte Gregersen, because he teaches at Aalborg University. I found Steen Møller through the DR-website for the television series about Friland. Jørgen Munch-Andersen, who was the co-author of a report about straw bale building for Danish Building and Urban Research, pointed me towards Caroline Mayer White.

I am confident that the interviewees I have chosen are appropriate since it is hard to imagine what I would ask people who had no clue of what a straw bale house is. I could perhaps have interviewed or surveyed a sample of people to find out if they had heard of straw bale building, and if they would consider it if they had, but that would only provide quantitative data and not much in-depth knowledge of the specific problems related to the diffusion of straw bale building.

3.3 The interview

The interview was conducted in an informal manner, which means that there were no strict sequence of questions and manner in which they were asked. If I wanted to compare the interviewees against each other, a formal interview would have been a better choice. But since I was interested in gathering information about as many different building experiences as possible, in order to understand as many problems as possible, the informal interview was deemed more appropriate.

The questions were open-ended questions, that is, questions that required more than a ‘yes’ or ‘no’ answer. The interviewees could call to mind relevant information and decide themselves what they felt were important aspects of a theme. The interview guide was constructed so that if an interviewee had no ready response to a question, there would be follow-up questions at hand, with examples of which topics he or she could talk about.

I tried to follow the sequence of questions that I had prepared in the interview guide as much as possible, but that did not always work out, since the interviewees were eager to jump to other themes on their own initiative whenever they thought of something else they wanted to say, and in order to get the most relevant information I let them do that.

I used Steinar Kvales book “Doing Interviews” as guidance in the creation and conduction of the interviews. Kvale stresses that it is very important to choose your questions carefully to avoid any unpleasant surprises when transcribing, for example that one has not asked the right questions at all. This is why I chose to relate the questions to specific themes in Roger’s theory.

All except for one of the interviews were conducted face to face, meaning via Skype or in real life. One of the interviewees, Roar Lefsaker, answered via e-mail. This makes his interview shorter and less detailed than the others. Nevertheless, I chose to include it to widen the amount of data collected.

The duration of all the interviews conducted via Skype or in real life was approximately one hour. The real life interviews were conducted in Oslo, Aalborg, and Friland. At Friland I got a tour around the area to see the many straw bale houses that are built there and experience

straw bale buildings up close. The interviewees were either at their homes or offices while being interviewed, which I hope made them more confortable and open during the interview.

The following is a list of the dates when the interviews were conducted and their location:

30.04.13: Rolf Jacobsen, at his office in Oslo.

22.05.13: Piet Jensen, video conversation via Skype.

23.05.13: Ole Busck, at his office in Aalborg.

29.05.13: Roar Lefsaker, answered via e-mail.

06.06.13: Tove and Anders Sanderhoff Sørensen, video conversation on Skype.

12.06.13: Ingrid and Fridrik Bertelsen, video conversation on Skype.

18.06.13: Caroline Meyer White, at her home in Friland.

18.06.13: Steen Møller, at his home in Friland.

I tried to meet any ethical issues by asking all interviewees beforehand if I could record their interviews. I got their permission to use their real names in my thesis, that is, none of them wanted anonymity. All interviewees were offered a citation check; I sent them the passages that contained material from their interviews for approval, so that possible misunderstandings could be cleared up before printing of the thesis.

Even though the interviews were informal and on occasion had sidetracks of random conversation, I think that I avoided attitude forcing and leading questions, because I let the interviewees speak freely.

The gender composition of the groups of interviewees was biased towards the masculine. Out of ten interviewees there were three women. I did strive to find female interviewees, but it is likely that the topic being construction, men would predominate in the field, since traditional gender roles are still present in the Nordic countries.

The interview guide can be found in Appendix B.

3.4 Analysing interviews

The Miles and Huberman Framework for Qualitative Data Analysis divides data analysis into three main components: *data reduction*, which happens through editing, segmenting and summarizing; *data display*, which is to organize and assemble information; and *drawing and verifying conclusions*, which can be done on the basis of reduction and displaying. (Miles and Huberman, 1994, cited in Punch, 2005, p. 197)

I used this step-by-step process when handling my qualitative data. After conducting the interviews I transcribed them in my native language. I then grouped the different parts of the answers under their appropriate themes as related to Rogers' theory of diffusion.

Then a summary was translated to English and inserted in the empirical sections of the thesis. I then used the theory to discuss what the answers meant for the diffusion of straw bale building.

Punch points out that this kind of segmentation of the data is not without complications. Since the interviewees are telling a narrative, loss of meaning and of important information might

occur when one disconnects pieces of the narrative from the surrounding text. (Punch, 2005, p. 217) I have kept this in mind when I analysed the interviews and tried to keep the interviewee's whole story as background when summarizing and categorizing what they said.

3.5 Validation

Validity is a term used in social research and has several meanings. Generally, it has to do with how well the research describes reality; how well the research measures the targeted phenomena and how well the results reflect those phenomena. (Punch, 2005, p. 97)

Internal validity refers to the internal logic and consistency of the research. It is important that the components of the research fit together, because "we can have little confidence in the answers put forward to research questions on the basis of a design and methods which do not fit with each other, or with the questions." (Punch, 2005, p. 247)

In order to achieve internal validity I started with defining research questions I wanted answers to and then contemplating the best way to find those answers, rather than first collecting data about straw bale building and then looking for what it might answer.

A threat to my research's internal validity could perhaps be that the collected data comes from biased individuals, meaning that they are naturally very positive to straw bale building, having chosen to work with it or use it in their houses. Had I randomly selected interviewees and asked them about their knowledge and attitudes of straw bale building I might have found other and/or complementary answers to my research questions.

External validity has to do with how far the findings of a study are generalizable and if the conclusions can be transferred to other settings and contexts. (Punch, 2005, p. 255) A shortcoming in my research could be that the context of the research is not described in detail and therefore it might be hard to judge if the findings regarding straw bale building are applicable in other countries as well.

Norway and Denmark are in many respects similar, but there is also variation, and compared to non-Nordic countries even more differences, given the many building styles and traditions, climate conditions, and numerous other factors that are country specific. Therefore, this study only speaks for Norway and Denmark, and other country specific studies regarding straw bale building would have to be carried out in order to say something about the general obstacles straw bale building has in its diffusion.

4. Diffusion of innovations

4.1 Origins

Before we dive into the concepts of the Diffusion of Innovations theory, a definition of innovation is in order. Innovation is not the same as invention, although they are closely linked. “Invention is the first occurrence of an idea for a new product or process, while innovation is the first attempt to carry it out into practice” (Fagerberg et al., 2005, p. 4)

Innovations can be product innovations or process innovations, meaning new or better material goods or services, and new and better ways of producing goods and services. Both innovations can be technological or organizational. (Edquist, 2005, p. 182)

Not all inventions become innovations right away, like for example Leonardo Da Vinci’s ideas for flying machines. And even if one does put an idea into practice, there needs to be commercialization and diffusion of the new product or process.

Everett M. Rogers defines an innovation as “an idea, practice, or object that is perceived as new by an individual or other unit of adoption. It matters little, so far as human behaviour is concerned, whether or not an idea is “objectively” new as measured by the lapse of time since its first use or discovery.“ (Rogers, 2003, p. 12)

It is upon this definition this thesis rests. Straw bale building is not an objectively new innovation, since people have built with straw and clay in various forms throughout the times, and straw bale buildings have been around for more than a hundred years. But it is perceived

as something new in our society due to the lack of its wide diffusion, and is therefore worthy of being called an innovation.

Diffusion of innovations has been studied from several different perspectives. Rogers' theory is part of the sociological and organizational literature of diffusion. There are also historical, economic, and network theoretical perspectives. While sociologists and organizational behaviourist focus on the external environment, economists prefer to look at the innovation in terms of "cost and benefit" as decided by rational individuals in an environment with limited information and uncertainty (Hall, 2005, p. 461).

4.2 Rogers' theory

"Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system." (Rogers, 2003, p. 5) It means that the four main elements in a diffusion campaign are the innovation, communication channels, time, and the social system, and that they should be studied in order to find out if an innovation is diffusing successfully.

Rogers describes in detail these aspects with concepts like *five perceived characteristics of innovations, the S-curve, adopter categories, communication channels, time,* and more. In the following I explain what is meant by these terms.

4.2.1 Five perceived characteristics of innovations

The rate at which an innovation diffuses is highly dependent on the characteristics that potential adopters assign to it. (Rogers, 2003, p. 219) There are five main characteristics as outline by Rogers.

The first is the *relative advantage* of the innovation, or, whether the innovation is perceived as better than the existing alternatives, and includes economic, social, or other advantage.

The next characteristic is the innovations *compatibility* with the adopter's values, past experiences and needs.

The *complexity* of the innovation is defined as the degree to which it is perceived as easy to understand and use.

Trialability has to do with whether or not a potential adopter can try out and experiment with the innovation on a limited basis.

The last characteristic is *observability*, which means the degree to which the results of an innovation can be observed and communicated to other people. For example, the *hardware* aspect of an innovation, for instance the components of an actual computer hard drive, is more easily observable than the *software* aspect of it, like the software programme that the computer uses.

All these characteristics are connected to the rate of diffusion of an innovation, positively or negatively. "Innovations that are perceived by individuals as having greater relative

advantage, compatibility, trialability, and observability and less complexity will be adopted more rapidly than other innovations." (Rogers, 2003, p.16)

4.2.2 Rate of adoption

Most innovations have a rate of adoption that follows an *S-curve,* that is, the number of people adopting an innovation has a cumulative frequency, and if one follows the distribution over time, an S-shaped curve emerges. But the slope of the S varies between innovations. Some new ideas diffuse rapidly and have a steep S-curve, while others have a more gradual S-shape, and some innovations never take off on the cumulative climb and never fully diffuse.

When enough people have heard about in innovation, its diffusion becomes self-sustaining. "The *critical mass* occurs at the point at which enough individuals in a system have adopted an innovation so that the innovation's further rate of adoption becomes self-sustaining." (Rogers, 2003, p.343)

4.2.3 Time

There are three time dimensions involved in diffusion of innovations: (1) The innovation decision process, describing the timeframe during which an individual goes from first knowledge of an innovation, to adoption or rejection; (2) The innovativeness of a person, or, how early or late they adopt an innovation, which we will take a closer look at in the next sub chapter; and (3) An innovation's rate of adoption in a system, as exemplified by the already mentioned S-curve.

Rogers describes the innovation decision process happening in five stages. (Rogers, 2003, p. 169) The knowledge stage is when an individual or other decision-making unit gains knowledge of the existence of an innovation and how it functions.

The persuasion stage is when a favourable or unfavourable attitude towards the innovation is formed. The decision stage takes place when adoption or rejection of the innovation occurs, which then leads to the implementation stage when the new idea or product is put to use.

Lastly, in the confirmation stage the adopters seek reinforcement of the innovation-decision that has been made, and can reverse it if they come across something that make them reconsider the decision.

4.2.4 Adopter categories

The *Bell-curve* divides *adopter categories,* which is a classification of members of a social system on the basis of innovativeness, according to how fast they adopt an innovation. *Innovativeness* means in this context the degree to which an individual, or other unit, is relatively earlier in adopting new ideas than other members of a social system.

These categories are: *Innovators, early adopters, early majority, late majority*, and *laggards*. The people in each category have certain characteristics in common regarding socioeconomic status, personality, values and communication behaviour.

For our purpose I will shortly outline what the theory generalizes about innovators and early adopters. Note that this description does not mean that all those who fall into the category have these characteristics, or have all of them.

Generally innovators are venturesome types. They are interested in new ideas and communicate with likeminded people in both local and cosmopolite networks. They have the ability to understand and apply complex technical knowledge and can cope with a high degree of uncertainty about an innovation at the time when he or she adopts it. Further, they are likely to have financial resources that help them take any losses from an unprofitable innovation, but it is not a prerequisite. They have a desire for the daring and risky. (Rogers, 2003, p. 283)

Early adopters are more integrated in the social system than innovators. They tend to be more localites rather than cosmopolites. Early adopters have the highest degree of opinion leadership in most social systems; they serve as role models for many others in the system. Their peers respect them because of their ability to make good innovation adoption decisions. The early adopter decreases uncertainty about a new idea by adopting it, and thereby helps furthering the diffusion of it.

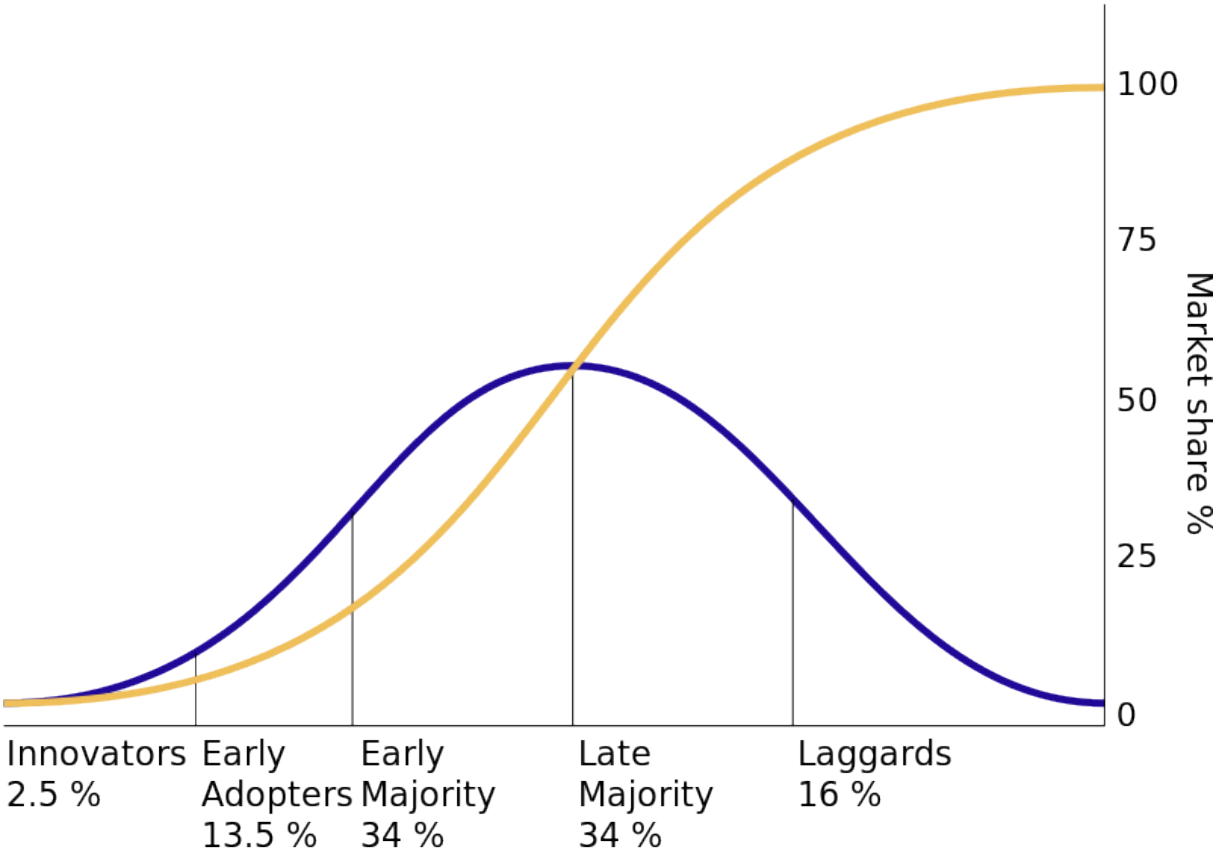

Figure 1: *Adopter categories (Bell-curve) are illustrated by the blue curve, and the rate of adoption (S-curve) by the yellow curve. Image released to public domain, for any purpose, on Wikipedia.com.*

4.2.5 Communication channels

"The essence of the diffusion process is the information exchange through which one individual communicates a new idea to one or several others." (Rogers, 2003, p. 18)

The process involves an innovation, an individual that has knowledge about an innovation, who conveys it to an individual that has not this knowledge, through a channel that connects them.

Mass media channels create awareness-knowledge about an innovation in a large audience, but *interpersonal channels,* like face-to-face interaction, are more effective in convincing a potential adopter to adopt, because he or she is dependent on the experience and evaluation of near peers. (Rogers, 2003, p. 205)

Homophiliy is an important aspect in the communication between adopters and potential adopters in that the transfer of ideas occurs most frequently when the individuals are similar in beliefs, socioeconomic status, education or the like. (Rogers, 2003, p. 19) But this can also act as a brake on diffusion because people tend to speak to likeminded people and might not possess information that is new to the other person. This may cause the innovation to diffuse *horizontally*, meaning among similar categories of people, rather than *vertically*, where the new information could reach a wider range of people. (Rogers, 2003, p. 306)

Heterophilous communication is not without problems either. For example, when a person with a technical background tries to convince a "technophobe" to adopt a new and complicated gadget, he or she may be waved off. However, if another person who was known for not being very tech-savvy suggested it, the "technophobe" might consider it because a similar person had already tried it.

4.2.6 Social structure

The social structure of a system affects an innovation's diffusion in several ways. Most social systems have a hierarchy of some sort, and the diffusion of innovations is influenced by this structure, as well as by the social norms in the system.

The most innovative members of a system are very often perceived as deviants from the social system and have low credibility by the average members of the system. Innovators are therefore dependent on opinion leaders to spread their ideas. *Opinion leadership* is the degree to which an individual is able to influence the attitudes or behaviour of others in the social system. Opinion Leaders are typically more exposed to mass media; they are more cosmopolitan and have more contact with change agents. They have higher socioeconomic status and are more innovative. (Rogers, 2003, p. 26)

Since direct information and leading by example are more effective than for example commercials, opinion leaders play a big part in the success of an innovation's diffusion. The social norms of a system are also important for the context of an innovation's diffusion. Norms define tolerable behaviour and serve as a standard in the social system, and they can act as barriers for new ideas if they don't comply with the established and acceptable way of doing things.

4.3 Criticism

According to Rogers himself there are four criticisms of diffusion research. The *pro-innovation bias* has to do with the assumption that all members of a social system should adopt the new innovation, and that it should be neither re-invented nor rejected. It is most often evident in research that is funded by the *change agents*, someone who have an interest in the innovation's successful diffusion. (Rogers, 2003, p. 106)

Individual blame bias means "the tendency to hold an individual responsible for his or her problems, rather than the system of which the individual is a part" (Rogers, 2003, p. 118)

The recall problem has to do with the time that has passed between someone adopting an innovation and being asked to remember it. Diffusion research depends on self-reported recall data from the respondents, and hindsight is not always completely accurate. (Rogers, 2003, p. 126)

The issue of equality is concerned with the fact that diffusion researchers have not paid enough attention to the consequences of innovations, and, more importantly, how the socio-economic benefits of it is distributed among individuals in a social system. The diffusion of an innovation can increase the socioeconomic inequality in the system, and inequality can be a determinant for some individual's lack of access to an innovation. (Rogers, 2003, p. 130)

Hall (2005) points out that diffusion researchers have assumed that the new innovation and what it replaces do not change during the diffusion process, and that this view has been challenged. It is argued that the innovation improves as user feedback accumulates, as do the old innovation due to competitive pressure. Rogers address this point and states that an innovation diffuses more rapidly, and that its adoption is more likely to be sustained, if it can be re-invented during the adoption process. (Rogers, 2003, p. 17)

5. Diffusion of straw bale building in Norway and Denmark

"It is a long way from seeing a straw bale house on TV,
to thinking that that could be something "I" could do too."
Tove Sanderhoff Sørensen (06.06.13)

5.1 The Innovation

Rogers points out in the beginning of his book:

> *"Getting a new idea adopted, even when it has obvious advantages, is difficult. Many innovations require a lengthy period of many years from the time they become available to the time when they are widely adopted." (Rogers, 2003, p.1)*

Diffusion is difficult for many advantageous innovations, it seems, and so straw bale building is in no way unique. In the following we take a look at what characteristics of straw bale building could be inhibiting its diffusion using Roger's five perceived characteristics of innovations as guidance.

5.1.1 Relative advantage

As mentioned in the previous chapter, the relative advantage of an innovation is how advantageous it is perceived compared to what preceded it. In this section I analyse the advantages and disadvantages of straw bale building as perceived by those who have built a straw bale house, as well as present what the experts had to say about the relative advantage of straw bale building.

5.1.1.1 Advantages and disadvantages

Fridrik and Ingrid Bertelsen think their future maintenance costs will be far less because they built a straw bale house, since they will not need to paint it every decade or so. They also said they save money on their energy-bill since the house is well insulated. The house is warm in winter and cool in summer, and the diffusion openness of the walls provides excellent indoor climate, something many people visiting the house notice. It feels stable and solid. There is a lot of flexibility and freedom in the design. One can build a round shaped "hobbit house", or one can go for the streamlined angles of a modern home, they said. (12.06.13)

Ole Busck also highlighted the insulations properties and the indoor climate of his straw bale house, as did Tove and Anders Sanderhoff Sørensen, and Roar Lefsaker. Roar also mentioned the use of a local resource as an advantage of straw bale building, and that one can do much of the work by oneself and use recycled materials. (23.05.13)

Fridrik and Ingrid's house is a pilot project in Norway; it is the first house built only by contractors and thereby an example of how much a straw bale house would cost if one outsourced all the work. Fridrik and Ingrid estimate that the house turned out slightly cheaper than a similar normal architect designed house. They are also convinced that with time and more rationalization of the building process, it could become even more affordable to build straw bale houses. (12.06.13)

Ole Busck said that his house was cheap in materials, while other things were at the same cost as in a traditional house, like the kitchen and bathroom. There is also the issue of the value

one assigns to ones own working hours, which Ole used a lot of. But all in all he figures that the house is cheaper than a similar traditional house. (23.05.13)

Tove and Anders think their house is at the same price level as a normal house. It is not cheap, but it could be, they said, because straw is cheap. But if one outsources most of the work it evens it out, because building it is a time consuming process. Some of the other materials they chose were more costly and tipped the scales towards a normal price range for a standard house, but they are happy with the fact that they chose good quality materials. Tove and Anders said that they are happy about the fact that they have a house that not everybody else has, and that their house has ”soul and character”, as they put it. The atmosphere in straw bale houses is very special and cosy, they said. (06.06.13)

Though the builders see a lot of advantages with straw bale building, there is also a flip side of the coin. It was not easy to find a carpenter, Tove and Anders said. Even though they are doing a lot of the work themselves, it would be nice to have someone who could take over if they got tired, but straw bale builders are harder to come by than traditional builders. It takes time to learn the ropes of straw bale building, and if he has to explain everything to a carpenter, he might as well do the job himself, Anders said. They have a friend who is the official carpenter on the project, but since he is not a straw bale builder, they are both learning how to do things as they go along. There are no ready-made solutions, they said. (06.06.13)

Finding the right materials can also be a challenge, in Tove and Anders’ opinion. If one wants to keep the environmentally friendly profile of straw bale building, which is one of the things that appealed to most of the builders in the first place, finding the right materials is not as easy as just going to the building store and picking them out. One has to do a lot of research and

look for small and out of the way producers that have what one is looking for. Tove and Anders said that the process is also a lot of fun, because one can come across a little sawmill that has just the right timber for one's house, but that it takes more effort. (06.06.13)

Roar Lefsaker said he has had some challenges with an outer wall exposed to wind and rain, and as a result plaster has come off. These kinds of maintenance issues can be pricey, in his opinion, and is a drawback if one is unfortunate to come across these problems. (29.05.13)

Fridrik and Ingrid Bertelsen said there is a potential for some surprises during the first couple of years of living in the house. Also they have had some issues with loose plaster, but in their case it was an issue of a silicate finishing that was not put on the clay plaster due to time constraints. They also mentioned weather considerations during the building process as a challenge. They had the plastering work done in the autumn, when frost already set in at night, which made the clay plaster vulnerable. They had to dry the plaster with fans and keep the building wrapped in a protective cladding. There are possible damages that can occur, and one just has to experiment before one has a permanent solution, they said. But none of their damages were so severe that they could not be easily fixed, Ingrid and Fridrik said. (12.06.13)

5.1.1.2 The expert's view

Caroline Meyer White said that the techniques of straw bale construction does not fit with what traditionally trained craftsmen have learnt, and that it has kept professional builders hesitant about building straw bale houses. Another issue, she said, is that there has not been enough documentation of the properties of straw bale houses. It is just now tipping the point where the documentation is getting there, which is making it more accessible. But still, at the

moment, if a carpenter or mason wants to take on straw bale construction he is taking on an enormous risk compared to what he is used to, Caroline said. (18.06.13)

Regarding economy, Rolf Jacobsen said that one should not expect a straw bale house to be cheaper than a normal house. ”It depends on what value one assigns to the different qualities one gets in a straw bale house, like indoor climate and low energy consumption. One could save some money in the long run,” he said. (30.04.13)

Piet Jensen said that people often ask him whether a straw bale house is cheap. “We must tell them that we cannot build it cheaper than a regular house. But in return you get a healthy house that breathes. It deters most people, they think that when it is environmentally friendly it is also cheap,” he said. Piet also said that those who have built a straw bale house are very satisfied with the indoor climate and the house in general. “It is not the results that are negative. It is the process of building that scares people,” Piet said. Also, since all straw bale houses are constructed as more or less experimental buildings that one cannot classify, and which there are no building standards for, provides a degree of uncertainty. Not everyone can live with that, Piet said. (22.05.13)

Steen Møller said that there has not been enough focus on the exceptional indoor climate in straw bale houses. “We have made too little of this aspect, as there is no competition in this department. Of course, it should be examined and documented, but it is difficult. One can examine an indoor environment and demonstrate that the indoor air quality is bad, but it is difficult to prove that there is good indoor air quality. However, you are never in doubt when entering a straw bale house,” Steen said. (18.06.13)

5.1.1.3 Implications

It seems there are both positive and negative sides to straw bale building. All the builders mentioned energy-efficiency, use of natural and sustainable materials, and a comfortable and healthy indoor climate as advantages of straw bale building.

An issue with straw bale building is the availability of straw bales. During bad harvest years straw might be hard to come by, and if one does not plan well ones building could be severely delayed. This makes it a "risky business". However, if an entrepreneur were to collaborate with the farmers, "book" the straw bales in advance, and store them for when they are needed for building, there might be a way around bad harvest years, but it requires storage space and confidence that they will eventually be sold.

Surprisingly the economic aspect of straw bale building was not as highlighted as I would have expected it to be. Some of the houses turned out cheaper compared to traditional ones, but it did not seem that it was something that was very important to the builders that I interviewed. This could be a sign that people in Norway and Denmark have the luxury of choosing their housing from different, and perhaps to them more important, criteria than economy alone.

As disadvantages they mentioned the vulnerability of clay plaster to weather conditions. It is important for people to know that the house they build is sturdy, will last, and at least tolerates rainfall. If not careful planning is applied, the straw bale house does not deal with rain as well as a wooden or brick house. This grain of doubt about the water resistance of a straw bale house could be one of the reasons why people might consider other alternatives.

Perhaps an even bigger hurdle might be the fact that there are not many straw bale contractors. For regular people, with no building experience, it might be enough to make them order a standard prefabricated house and be done with it. This also applies to the availability of natural and sustainable building materials; if people do not know where to get them, they probably will not get them.

Rogers says that diffusion scholars have found relative advantage to be one of the strongest predictors of an innovation's rate of adoption. He mentions economic profitability, low initial cost, a decrease of discomfort, social prestige, saving of time and effort and immediacy of reward as sub dimensions of relative advantage (Rogers, 2003, p. 233)

In light of this, it seems that straw bale building scores well in some areas, while having trouble in others. The initial cost for example: not many people take building their house lightly, as it is probably the major investment in their lives. To experiment with something that is perceived new and risky would to many seem foolish. On the flip side, there is a possibility of economic profitability, decrease of discomfort and some social prestige in some circles. It would be up to the individual house builder to assess which features of relative advantage are most important to him or her.

I will return to some of the disadvantages the builders mentioned when treating complexity in a following subchapter.

5.1.2 Compatibility

"I think straw bale building has been connected to the idea of a certain lifestyle; the idea that if you live in a straw bale house you also have to wear a big sweater and flat shoes"
Caroline Meyer White (18.06.13)

Rogers states: "an important factor regarding the adaptation rate of an innovation is its compatibility with the values, beliefs and past experiences of individuals in the social system." (Rogers, 2003, p. 4)

5.1.2.1 The builder's choice

The next step is to analyse why the builders chose straw bale houses, and why they thought it was the right fit for them, in order to find out what could be the reason for other people not choosing straw bale houses.

Ole Busck talked about the fact that he is a craftsman, a smith, and is used to working with his hands as a reason why he felt that to build a straw bale house was something he could do. Both his wife and he were very environmentally conscious and interested in having a different lifestyle. In light of this, a straw bale house seemed appealing. They would never have considered a house with pressure-impregnated wood. An important principle for them was that the house should not become garbage when it was torn down. Natural materials like wood, straw and clay do not pose a threat to the environment and can be found in abundance in nature, Ole said. (23.05.13)

The reason Tove and Anders chose straw bale was that they wanted a healthy house with good indoor air quality and no degassing of chemicals. They had to build a new house at their farm to replace an old wooden house, and when Anders heard about straw bale building from a colleague, the wheels were set in motion. The idea of a new house, but one that was not ”store-bought” and had more charm and “soul” was what made them take the leap. The environmental benefits, the use of natural materials, and the degradability of the house after it has served its purpose, were an added bonus, they said. (06.06.13)

Roar Lefsaker said he saw the opportunity to build a straw bale house as something interesting to experience. The environmental profile and use of local resources seemed appealing. The breathability of the structure also nudged him to become a straw bale builder. (29.05.13)

Ingrid and Fridrik’s story of how they got to have a straw bale house is somewhat complicated. They had bought an old wooden house that they fixed up, but became interested in sustainable building and decided to build a small straw bale atelier in their garden. But the night before they were set to move in their newly redecorated wooden house, it burnt down to the ground. They were unsure of what to do next, but one of the options that emerged was to build a new house with straw bales. They already had 250 bales for the atelier, but needed many more if they were to have a house. It was September and the farmers were done with their corn harvest, so straw bales proved hard to come by. After a lot of doubt and searching for straw bales, they found a farmer with enough to spare and a decision was made: they would build a straw bale house, they told me. (12.06.13)

5.1.2.2 Environmental philosophy

"I think it would be better if people bought expensive shoes and repaired them when they got worn out, instead of consistently buying cheap new shoes. I simply think that that is wasteful."
Anders Sanderhoff Sørensen about "throw-away society". (06.06.13)

I asked the builders of their thoughts and opinions about environmental issues to find out if the straw bale house was a parte of a larger ideology and a piece of a "package" of environmentally friendly choices.

Ole Busck said he is interested in *degrowth*; he thinks we could have a well functioning society without endless economic growth, which he sees as such an ingrained paradigm in our society that it is making people unhappy and destroys the planet. After the credit crunch and euro crisis of the last few years, people are so concerned with unemployment and getting the economic engine running again, that they have lost sight of the alternatives, he said. Ole sees it as a necessity that we limit our consumption of energy and unsustainable resources. He has installed solar panels that provide his electricity and tries to live a sustainable lifestyle, even though he said that he is not "holy". But when it comes to the important parameters, like building one's house, Ole thinks sustainability should be an important part of it. (23.05.13)

Tove and Anders are both concerned with healthy living and preservation of nature. They would not consider themselves extreme, but think they are more concerned with these things than the majority of the population. Through their research of straw bale building they came in contact with other people with similar interests and were even more inspired and motivated to make more sustainable choices. They buy ecological and local food when available,

especially eggs and meat, since animal welfare is important to them. They also try to make things last as long as possible and prefer good quality things that lasts a long time. (06.06.13)

Roar Lefsaker also mentioned ecological farming as something he deems desirable and is interested in. He also said he strives to use environmentally friendly products whenever possible. (29.05.13)

Fridrik and Ingrid also mentioned ecological food as part of the environmentally conscious choices that they try to make. As far as the budget allows it, they try to make good choices when it comes to their consumption of clothes and things. Ingrid has a past from the Norwegian environmental organization Future in our Hands, and Fridrik mentioned that he has many friends who are environmentally conscious and alternative. He became interested in sustainable building by chance, and the more he read about it the more certain he became that it was the right way to go. They both think modern houses of today are not only unhealthy for the inhabitants, but also for the environment. After their house burnt down they lived in a standard mass-produced house and decided that they would not have anything like it, they said. (12.06.13)

5.1.2.3 The expert's view

In Rolf Jacobsen's experience there are three categories of straw bale builders, but some can fall into several of them at once. There are those who are very environmentally conscious and realize that straw bales are some of the most environmentally friendly and climate neutral materials there are. Then there are those who think straw bale houses are charming and like the looks of them, with their organic forms and deep windowsills. Lastly, there are people

who think they have found a very cheap and easily accessible building material and can save a lot of money by using recycled materials and straw bales, especially if they do much of the work themselves. (30.04.13)

Caroline Meyer White said that the sustainable part combined with the economical part is what appeals to most straw bale builders in Denmark, because people see it as a way to be free. People think, "When I build this cheap house I will not have a mortgage or pay rent, I will be free. If I want to keep my job, I can, if I don't, I can quit and I will get my life back. Those are the thoughts behind it," she said. (18.06.13)

Steen Møller also said that the Danish builders have an urge for freedom. "A part of it is that they want to create things themselves, they have an urge to do so, and that they want greater independence. Some are mostly interested in the indoor air quality because of a medical condition, for example allergies and such, but they constitute a smaller portion. Most people want to show that there is another way, for themselves and partly also for society", Steen said. He also said that when he talks to people about their straw bale houses it is not the environment they talk about. They would rather talk about the process of building, Steen said. (18.06.13)

Piet Jensen said that the builders he has encountered very often are foreigners in Norway. Often they have an attraction to the countryside and prefer the organic side of things. "We have also had some that are ordinary people, and who sometimes do it as a gimmick. They have money and can afford a bit of everything. But generally, they are people with fewer resources that want to build and make some effort themselves," Piet said. (22.05.13)

5.1.2.4 Implications

A question that arises is whether there are enough people with the necessary engagement in issues related to the environment and sustainability to provide a large enough customer pool for straw bale houses.

Many have heard from politicians and activists in media of the pressing need to cut greenhouse gas emissions and halt the depletion of the earth's resources, but for many, it could be too large an undertaking to build their house with only sustainable materials. It seems that there has to be a passion and a strong conviction to choose the "green" alternatives.

We might be at the starting point of more and more people becoming concerned with environmental issues, and many more straw bale builders might come along as they learn about sustainable building alternatives. On the other hand, there are so many issues in the world today that demand people's attention, that people might feel that they are just a drop in the ocean in the larger scheme of things, and become discouraged to make the harder, less accessible, but more environmentally friendly choices.

5.1.3 Complexity

As mentioned before, a high degree of complexity of an innovation has a negative effect on the diffusion of it. If the innovation is hard to comprehend or difficult to execute, it means that it will also have a slower rate of adoption.

I asked the builders to recall any trouble or problems they may have encountered while building their straw bale house to see if maybe the complexity of building with straw bales, the process of getting a building permit, or other complications, are what keeps most people from trying it.

Tove and Anders said that it takes them longer to build than they initially thought. They have not moved in yet, but are aiming for some time next year (2014). They admit, though, that it may not be entirely the straw bale house's fault, but the combination of work, family life and other chores that get in the way. A more serious problem is how to keep the building dry during construction. It takes more time to get a weather proof building, Anders said, since the story divisions have to be installed first, then the roof, and then walls the last. He used countless hours to repair covers that had blown down, and the timber frame got a bit weathered during construction. A standard house would become waterproof much faster, he said. (06.06.13)

Roar Lefsaker said that their architect had to do more work with documentation and description of the feasibility of constructing the house before they could get their building approval from the authorities. (29.05.13)

Fridrik and Ingrid describe a similar experience, they had to meet with the municipality on several occasions to convince them, and provide much information and documentation, which took a lot of work beforehand. Other than that, they said they did not encounter any problems during construction. (12.06.13)

Ole Busck could not recall any problems he encountered during the building process. He had guidance and help from people who had already built straw bale houses, and experienced a lot of openness and interest from contractors that came to look at the building. He had no problem obtaining a building permit from the municipality. He found materials in the surrounding area and used timber from his own land. It was time consuming, but other than that there were no problems, he said. Ole and his wife had quite a bit of starting capital when they began building. He said he doubts that he would have gotten a loan from the bank if they had not saved up some money and just approached the bank with drawings of a straw bale house. After all, the house would be the banks security. But after the house was built, he had no problem obtaining a loan with the house as security, he said. (13.05.13)

5.1.3.1 The experts' view

Caroline Meyer White said that the builders have to be very devoted to the process because they are taking on a lot of risks. "I find when I try to guide people who come to me and say "we want a straw bale house", that it is a much longer process, with more communication involved. There are so many unknowns that the client has to consider, many more than if he or she just asked for a brick house. To build a house is already an incredibly complex process and it just adds to that complexity," Caroline said. (18.06.13)

Steen Møller said that the lack of adoption of straw bale building is partly because it is confusing for people. It is a new technique and also very labour intensive. Furthermore, he said it is difficult to finance, that there is resistance from the banks, and that the resale value is uncertain. This is what he thinks makes most people not choose a straw bale house. (18.06.13)

Piet Jensen said that there is more risk than normal connected to straw bale building. “Straw is cellulose, an organic material that can rot. If you get moisture into a straw bale it is difficult to get it out again, and if you don’t it starts to rot. At the construction site everything has to be organized so that the bales are dry at all times. So there is some risk associated with it, and it is a process that not everyone is prepared for. Things should preferably be easy today. Straw bale building is not easy, it requires an effort,” Piet said. (22.05.13)

There have not been any problems with getting straw bale buildings technically approved in Norway, Rolf Jacobsen said. The documentation that is used is mostly international. There are no Norwegian standards or research one can lean on. ”Up till now it has been approved, but the situation may arise that we have to document more, and then we would have to do more research,” he said. In that case, he questioned who would pay for it. ”It is not easy to spot anyone who would have an economic interest in more straw bale houses being built, and who would be willing to pay for the research,” he said. (30.04.13)

Caroline said that the municipalities in Denmark have not necessarily been team players regarding straw bale building, but not a problem either. Since the report from Danish Building and Research it has been easier to go to them with the documentation in hand and say that the building will be done according to their guidelines. Experience from other municipalities have also helped, since one could direct them to a neighbour county, where they had already given permission to a straw bale house, for any questions, Caroline said. (18.06.13)

Steen Møller said the authorities have been cooperative. They may have some objections, but nothing one cannot work through and compromise on. Steen also said that it was important to collaborate with Danish Building and Research. “With the report in hand, it is like ‘Ok, there

are some papers on it.' But they could well have rejected it and said that it is not well enough known. But they say 'ok', that it does make sense," Steen said. (18.06.13)

Rolf Jacobsen said that an important development in straw bale building would be the industrialization of it. He sees this happening on different levels. The lowest level of industrialization would be that one created a network of straw bale producers that had standardized straw bales of a certain quality ready for building. But we are not even at that level, he said. The next level would be production of straw bale elements for building, like a framework in wood with straw infill and a layer of plaster, so there would be less work on the construction. "But then people could start thinking: 'why not use wood fibre insulation instead, since we're already building a framework'", Rolf pointed out. Straw bale building would have to start competing with other "green" prefabricated building elements.

Another development that could be taken further, according to Rolf, is the production of straw bales using heat during pressing. A binding compound called lignin is released and makes the bales hold their shape without the use of strings. "The advantage would be that it is easier to transport and handle, and they could be standardized, tested and documented. A normal straw bale comes in many shapes and sizes; it is no standard material," Rolf said. The bigger problem in Rolf's opinion is that there are not enough carpenters that take the job of building a straw bale house. If people could order a house where they would just have to turn the key, straw bale building could become an option for many more people, he said. (30.04.13)

Piet Jensen said that they have been trying to recruit more professional craftsmen to straw bale building for twenty years. "But the fact is that we are just a handful of interested professionals who started it and who constantly run it. I do not think we are more than fifteen

people in Norway working with it and willing to take responsibility for it. However, in Denmark there is a lot more," Piet said. (22.05.13) He has had to get professionals from abroad to help him on some of his projects.

Also Caroline Meyer White and Steen Møller have though about industrialization, which is why they are starting up with the production of straw bale elements for sale.

"First of all I think it would help the builders, because it means that you can make a foundation, which you already know how to do, put a roof on it, and leave the walls and all the insecurity to those who produce the straw bale panels. I think that could open it up for more professional construction. And because it is industrial we will be able to document, adjust, and refine it," Caroline said. (18.06.13)

Piet Jensen talked about the difficulties with getting straw bales in the first place, and then the time frame of building. "You have to go out to farmers and get a hold of straw bales. And I think that is a barrier. It is so hard to get hold of straw and one must make an effort. It means that if you are going to build with this year's straw you have to wait until September, then store it and do all sorts of preparation work during the winter," Piet said. "It is an obsolete way to build in Norway where people are used to making a phone call, order the house they want, and three months later there are trucks in the yard and elements are set up. Three months later one can move in. We are talking about a half-year period. That is something we cannot live up to," Piet said. (22.05.13)

5.1.3.2 Implications

The complexity of straw bale building would be important in people's innovation-decision process. If it is too much "hassle", so to speak, or too difficult to build with straw bales, many would choose not to do so. According to Rogers, "when an adequate level of how-to knowledge is not obtained prior to the trial and adoption of an innovation, rejection and discontinuance are likely to result." (Rogers, 2003, p. 173)

As it is today, it is required that the builders themselves do a lot of research and often also participate in the building. For people with no prior experience of building, or with limited time frames, it may be too much information and how-to knowledge to acquire, and they may chose a path of less resistance. A solution to this problem could be more professional straw bale builders that provide a house with little involvement from the customer in the building process itself; I assume the design process would be a different matter. The issue then becomes how to educate enough straw bale craftsmen, and if their competence level would be sufficient to completely leave out the research and information gathering efforts of the house owners, which judging from the interviews sum up to many hours of unpaid work.

Ready-made straw bale houses for sale could also be an option, but it is difficult to see who would start such an enterprise without first having a market for it. Gaia architects and Rolf Jacobsen have considered the idea, but as of today their plans have not been put into action.

It is not, as far as I can see, a case of straw bale building being inherently complicated. Given the right training and education, builders could build them efficiently and confidently. The

problem is that it is perceived as very complex in today's society that is used to ready-made, quick solutions.

5.1.4 Trialability

The trialability of the innovation has to do with the ease with which the innovation can be tested prior to its adoption.

All of the builders drew upon the experience of other straw bale builders to become certain that a straw bale house was a safe option. They visited other straw bale houses and talked to their owners about how it was to live in them, and what obstacle they may have encountered while building. The builders read books and other material about straw bale building that they came across, and talked to the experts in the field, like Rolf Jacobsen and Steen Møller.

Ole Busck characterized the collection of straw bale builders at Friland in Denmark as an "experience pool", which he thinks is important for new builders. (23.05.13)

Tove and Anders felt assured that Rolf Jacobsen knew what he was talking about and commissioned him to design their house. They deem him an important factor in how they became confident that straw bale building was a viable option. If they imagine the worst-case scenario, it is not worse than them having to tear down the straw bale walls and replace them with wood and traditional insulation, they said. Since the timber frame is load-bearing the structure would still stand without the bales, which makes them feel like the risk of building a straw bale house is not too big, they said. (06.06.13)

5.1.4.1 Implications

To try out a house is difficult. One can visit a straw bale house and look at it, but that would not be an authentic experience of how it is to live in it. Still, looking at straw bale houses should provide some degree of trialability, and help possible builders make a decision to build or not to build.

However, there are not that many straw bale houses, and they are not easily accessible to all potential adopters. It is not like walking into an electronics store to try out the newest smartphone. The shear scarcity of straw bale houses is the main problem for the innovations trialability, and not something that can be easily altered before straw bale building has diffused more.

Also, the building process itself seems like a process that should be tried before embarked upon. That is where straw bale workshops and courses come in. It gives people a chance to stack some straw bales and plaster with clay before deciding if that is something they want to do for their whole house.

5.1.5 Observability

Observability is the degree to which the results of an innovation are visible to others. (Rogers, 2003, p. 266) I would like to treat this aspect together with communication channels in the following section.

5.4 Communication channels

Communication channels are important in the diffusion of knowledge about an innovation, and include aspects like *mass media channels*, *interpersonal channels*, *homophily* and *heterophily*.

Some of the builders stumbled upon straw bale building by chance. Fridrik Bertelsen for instance came across the information on the Internet and started to follow the leads to more and more information. Anders Sanderhoff Sørensen heard about it from a colleague, and in his case the interpersonal aspect of learning from a colleague, and subsequently by consulting with Rolf Jacobsen, convinced him of the viability of straw bale building. Ole Busck said that he was involved in several ecology networks in the 90s, and that those networks introduced him to straw bale building, another example of interpersonal channels being important.

Since there are few straw bale builders that could function as these personal knowledge diffusers, the question arises whether there has been enough information spread through mass media channels to promote straw bale building.

In Norway there is a network of straw bale builders and enthusiasts called "Norsk Jord- og Halmbyggeforening" (NJH). They keep track of Norwegian straw bale buildings and organize workshops and seminars. Likewise, "Landsforeningen for Økologisk Byggeri" and "Folkecenteret for Vedvarende Energi" in Denmark have similar functions. These organizations are run on a voluntary basis and have not enough capacity for a large-scale campaign to reach the masses.

However, Rolf Jacobsen said that it is easy to get media attention about straw bale projects. He thinks that most of the Norwegian straw bale houses have been featured in local newspapers or other media. (30.04.13)

Also Caroline said that the information has spread mainly by itself and because people search for it. “It is not because the industry goes out and grabs people, it is the other way around. There has not been enough information spreading, and I guess that is because it is just now that one can build a good straw bale house and feel confident in what one is doing as a professional. The supplier side was not ready, so they have not made themselves known,” Caroline said. (18.06.13)

Rogers says that one of the most crucial choices in the entire innovation-development process is the decision to begin diffusing an innovation to potential adopters. There is usually a whish to diffuse as soon as possible, especially if the social problem or need that it seeks to solve is important. But, a change agency’s reputation and credibility depends on them only promoting innovations that will have beneficial consequences for adopters. (Rogers, 2003, p. 156)

Steen Møller said that there has not been spread much information about straw bale building beyond the television program that was made about Friland, precisely for this reason.

”’Everyone’ knows that there are straw bale houses, and knows that it is something one can do, but it has never been something decidedly advertised for, because the time has not been right. We should first have more experience and be confident in the product that we provide. I've been involved in developing many different houses and structures in the past twenty

years, and it is only now that I feel certain about the way we should do it," Steen said. (18.06.13)

Piet Jensen said that they try to get media coverage and that they usually do. “In a time when everything needs to be advertised and put on the Internet, it is clear that we have not done that much. We also have to be careful about how much we advertise, because we do not have enough people to serve the masses, if they came. We have to wait until passive-houses and low-energy houses become more expensive, so that the straw bale house becomes a definitely cheaper alternative,” Piet said. (22.05.13)

It seems that communication about the innovation has been lacking in the case of straw bale building. This may be one of the major reasons for why it is not diffusing more rapidly.

5.2 Evaluation and Reinvention

One of the criticisms towards diffusion research is that it does not focus enough on the reinvention of an innovation while it is diffusing. Many adopters want to modify the innovation to suit their specific needs. Some innovations are easy to modify while others are not. Lets take a look at what the builders said about their re-invention and evaluation of straw bale building during their adoption processes.

Ole Busck said it was super to live in the house, and an aesthetically wonderful experience. The fact that it was something he had created from the start also gave the house a special meaning for him. He would change the foundation if he were to build a straw bale house again. The point foundation under the pillars made the house sag a bit in places and make the

plaster crack. He would have made a foundation under the whole wall all around the house instead. After about half a year he experienced a leaky roof that had to be repaired, but the cause was a building error and not the straw, he said. (23.05.13)

Roar Lefsaker reported that the tenants in the part of the straw bale house that is a rental apartment are happy with the indoor air quality, environment and acoustics. The problem with one outer wall that was damaged by rain could have been solved with larger roof overhangs or other protection, he thinks. (29.05.13)

Anders and Tove think they would have organized the building process differently and been more prepared for the different phases of the building if they were to build again. Inexperience with straw bale building is why it has taken them a long time to build, they think. They would also have outsourced more of the work in order to have a roof on the house faster than they did. But they would still have chosen a straw bale house if given the chance of a redo, at least a house that was equally natural and environmentally friendly, they said. (06.06.13)

Fridrik and Ingrid think they would have accepted more offers from contractors before deciding which to use to make the house more affordable. Nevertheless, they are very happy with the quality that they got and the craftsmanship of the builders that were with them every step of the way. (12.06.13)

It seems that straw bale building leaves much room for experimentation when it comes to design, as do any other type of house. The process of building is not as clear-cut as building

methods that are more tried and tested. Therefore a high degree of re-invention in the building process is available.

Some of the problems the builders faced, like plaster falling off could easily be mended by re-invention, meaning larger roof overhangs, different design, or by applying different kinds of finishing. The problem is that one's house is not something most people might be willing to experiment with, since it is such a large investment.

5.3 Time

Ole Buscks said he first heard of straw bale building in the mid-90s. Seven years later, when the time came for him and his wife to find a new place to live, he realized the idea of a straw bale house. They started building in 2003 and moved in in 2005. (23.05.13)

Anders Sanderhoff Sørensen heard of straw bale building from a colleague in the summer of 2008, and enthusiastically told Tove about it. In the autumn the same year they contacted architect Rolf Jacobsen, and got the first drawings around Christmas. In 2009 they got a building permit from the municipality, and in April of 2010 the foundation work commenced. They are aiming to be finished with the house in the course of 2014. (06.06.13)

Roar Lefsaker could not recall exactly when he first learnt of straw bale building, but said it was "a long time ago". It became an option about ten years ago, he said. (29.05.13) The building at Holt gard was finished in 2009.

Ingrid Bertelsen first heard of straw bale building in 2002, when a building at a Steiner-school was built in the area. There were also straw bale workshops at Nesodden at that time, Ingrid recalled. Fridrik dates his first exposure to straw bale building to 2008. (12.06.13)

There is variation in the builder's adoption decision process. Some of them knew about straw bale building for years before they built, while others built the same year that they found out about the option. When to build a house is highly dependent on individual circumstances. It is not as easy as following the latest fashion in clothing, which most of us buy every year. If one does not need a new house, then one would not build a new house, straw bale or other. On the other hand, there is always someone out there looking for a new house, and the sooner they could gain knowledge about straw bale building being an option – it being the first step in the in the adoption process – the faster straw bale building could diffuse.

5.6 The expert's summary

"We depend on our surroundings obliquely to embody
the moods and ideas we respect and then to remind us of them.
We look to our buildings to hold us, like a kind of psychological mould,
to a helpful vision of ourselves."
Alain de Botton in 'The Architecture of Happiness' (2006)

To sum it all up, here are some last thoughts from the experts on why straw bale building has not become more popular.

Rolf Jacobsen said he thinks this is due to several reasons. Firstly, there is not enough knowledge about it in society. "You would have to be very interested in sustainable building

in order to even come across the idea. Another issue is that it is different that what is considered normal, so it would make 90 per cent of people not consider it," Rolf said. The third reason could be that there are not enough people one can go to if one does want a straw bale house. And last but not least, concerns about guarantees, security, durability and other uncertainties could make people shy away from straw bale building. "There is no straw bale building standard, so it would feel more uncertain than many other alternatives," Rolf said. (30.04.13)

Piet Jensen said that twenty years back they saw straw bale building as the ultimate way of building: one could take a building material lying out on the field and build with it. "We were sure it was going to take off. However, it has not. We have a maximum of one or two projects each year," Piet said. (22.05.13)

Rolf Jacobsen believes that there is a bigger demand for straw bale houses than there are suppliers. Over time, he thinks there could be built a hundred straw bale houses in Norway per year. He said there are many people that ask for it, but not many that deliver it. There are also few self-builders in Norway, Rolf said. Another major issue, according to Rolf, is that not enough knowledge and experience about straw bale building can accumulate, because the buildings are so few and far between. He said that NJH is run on a voluntary basis with little resources, and that that makes information work move a little slow. Regarding architects, Rolf said that they are seven or eight architects that design straw bale houses in Norway. (30.04.13)

Caroline Meyer White pointed out that many straw bale houses have been found lacking in the design department. "There are hardly any beautiful, well designed straw bale houses

where there has been an architect involved in Denmark. So many have been self-builders that also wanted to design themselves. And if that's not your main trade, maybe you're not so good at it. People today want things to be designed and detailed," she said. Caroline also said that she thinks the way forward is industrialization. "I am in a couple of international networks, in the US and Canada, Europe and Australia, and that is what they are all trying to do, because they see that we need to make something that is more adaptable with the existing to enter a bigger market," she said. (18.06.13)

"It is fine to go around and fiddle with half a per cent of the market, but there is potential for so much more. And now we know how to do it. It really took these twenty years to figure out the details. You don't need to invent anything anymore to build a good straw bale house," Caroline said. (18.06.13)

Steen Møller said that with industrialization they could educate people to put up straw bale element houses. "The craftsmen we have today are assembly workers, and they can also learn how to assemble a straw bale building. They would come in for a two-month course and off they would go. My plan was originally: first self-builders, then craftsmen, and then industrialization. But the craftsmen never came. There is no interest in stacking straw bales and plaster clay, wages are too high and it takes too long. That's why we go directly to industrialization now," Steen said. But it will take time, he thinks, because it is a completely different way of thinking. Most people need time to change their perspective of what a house is, and build confidence in a straw bale house, he said. (18.06.13)

In spite of all the difficulties with straw bale building Rolf Jacobsen said that after fifty years of intense technological development, the most advanced building technique we have are some straw bales we can pick up from the earth.

”Since the Second World War we have had enormous technological progress, and the building industry has developed thousands of new materials. Everything is done to create better, cheaper, smarter and more modern houses. But if you list some criteria on what is important, including environmental aspects, greenhouse gas emissions, fire resistance, insulation properties and so on, and check the different materials against these criteria, there is no doubt that straw comes out of it the winner,” Rolf Jacobsen said. (30.04.13)

6. Comparative analysis of straw bale building in Norway and Denmark

Below is a table that demonstrates the similarities and differences between Norway and Denmark regarding straw bale building using categories from Roger's theory. This summary is based on the previously presented data from the interviews with new information and citations added where appropriate.

	Norway	**Denmark**
Relative advantage	In common: All interviewees highlighted energy efficiency, natural materials, sustainability, indoor climate, and, to some degree, economy, as advantages of straw bale building. Country specific: More of the Norwegian interviewees assigned importance to the uniqueness charming aspects of the straw bale house.	Country specific: More of the interviewees highlighted economy as an important factor, and the connection to freedom from debt.

Compatibility	In common: Builders from both countries were interested in sustainability and environmentally friendly materials. Country specific: Rolf Jacobsen said that architects and straw bale contractors have been an important driving force in the building of Norwegian straw bale houses. (30.04.13) This could have a positive effect on straw bale building's reputation among the public and make it more compatible with their values and wishes regarding a home. Rolf Jacobsen thinks that there are few people in Norway that could be considered pioneers in ecology and that that makes the social context for straw bale building unfavourable. But he stresses that	Country specific: Danish architects do not engage in straw bale design, Steen Møller and Caroline Meyer White said. "There are no architects in Denmark that will touch straw bale building with a ten-foot pole, because it is considered low status," Steen said. (18.06.13) "There is a perception that has been attached to it that needs to be broken, but it is not a big deal and it is ready to happen. It is fine that there have been all these self-builders; it has made some innovation happen. But it is definitely ready for the next step where a new group is attracted,"

Compatibility cont.	he thinks many people in Norway are positive to the "green" and environmentally friendly developments, and could potentially try them if they were served up to them. (30.04.13) There are lots of wooden houses in Norway and it is considered the standard. This tradition might make people prefer wooden houses over straw bale houses.	Caroline said. (18.06.13) In Denmark, the brick house is the standard. Perhaps this similarity in appearance between a brick house and a straw bale house has made straw bale building more attractive in Denmark. Steen Møller said he thinks there is more conservatism in Norway, and that starting something new is difficult. He said it difficult in Denmark also, and even more so in Norway. On the other hand, Steen pointed out that Norwegians have a closer relationship to nature, and more respect for it. (18.06.13)

Complexity	In common: In both countries there are issues related to lack of knowledge and documentation, weather considerations during construction, and labour intensiveness. Country specific: Lack of straw bale contractors is a major issue in Norway and might be hindering diffusion even if a demand is present. Some parts of Norway may not be suitable for straw bale building due to humidity and heavy rain, as well as access to local straw, making it a viable option for a smaller portion of the population.	Country specific: There have been more self-builders in Denmark, which have made the designs and solutions more varied than in Norway, where many of the houses have been designed by architects and built by contractors. “The government is more open in Denmark. In Norway it is stricter and they want to talk to an architect. Here we come with napkin drawings and say "we want to make this". Almost,” Steen said. (18.06.13)

Trialability	There are fewer straw bale houses in Norway than in Denmark, which means it requires more effort to find a straw bale house to "try out" before making a decision to adopt the innovation. On the other hand, there are more architect-designed houses in Norway, meaning the houses that can be "tried" might be of higher quality and/or appeal to the average person.	
Observability and Communication channels	In common: Both countries have interest organizations and networks working with straw bale building, but no targeted PR-campaigns or strategies to actively promote straw bale building. Country specific: Piet Jensen said that he still keeps experiencing a "swearing in the	Country specific: Given the series about Friland on Danish national television, it can

Observability and Communication channels cont.	church" kind of situation if one talks too much about ecology in Norway. (22.05.13) There is an assumption that the Danes are more open minded when it comes to "green" issues, which is also apparent in the availability of for example ecological food in grocery stores.	be assumed that straw bale building has had more media-coverage in Denmark than it has in Norway. The difference in the number of houses also serves as an indication that straw bale building is more visible in Denmark.
Evaluation and reinvention	No found differences between countries.	
Time	Too little data to make a comparison.	

7. Conclusion

"Houses are amazingly complex repositories…
Whatever happens in the world –
whatever is discovered or created or bitterly fought over –
eventually ends up, in one way or another, in your house.
Wars, famines, the Industrial Revolution, the Enlightenment –
they are all there in your sofas and chests of drawers,
tucked into the folds of your curtains …
Houses aren't refuges from history.
They are where history ends up."
Bill Bryson in At Home – A Short History of Private Life (2011)

Rogers' theory proved adequate in providing a detailed framework for the various reasons why the diffusion of straw bale building is moving so slowly. With so many aspects being in play, and so many issues people must consider in choosing a straw bale house, it was necessary to illuminate them in a detailed manner. For most people, the decision of which house to build is a far more important decision to make than whether to buy the newest smartphone on the market.

However, an issue I found with the theory was that it was perhaps too detailed. There were some overlapping themes, that is, the answers to a question could fit into several of the categories, which made the decisions of where to put what in the thesis a challenge. A coherent story of the diffusion of straw bale building proved challenging to create, because the matter is treated so thoroughly in the theory that there is a chance of being repetitive and "loosing one's thread". Passages that would fit together could not be put together because it was "not their turn".

All in all I found the theory helpful in understanding what aspects are important to consider when studying diffusion of innovations. But perhaps the most useful were my interviewees. I got the feeling that this subject were a passion of theirs and that they had reflected upon the same questions that I had, namely why not more people build straw bale houses. They had read a lot about straw bale building and were very knowledgeable, which made interviewing them a breeze.

Returning to the research question, namely, why straw bale building has not diffused more, some aspects of the building technique emerge as important.

There has not been enough advertising and information spreading, mainly because the supplier side has not been ready, and because there are too few professional straw bale builders. Further developments on the supplier side and commercialization of straw bale building could further its diffusion.

There are few that have built straw bale houses, which leads to fewer interpersonal communication channels that could further straw bale building by opinion leaders influencing others to choose straw as building material. Builders could be more active in the promotion through for example “open houses”, which many of them already do.

Documentation for straw bale building has been scarce. In Norway there has not been any documentation, while in Denmark there is a report from Danish Building and Research from 2004 that one can lean on. Still, dependence on international documentation might alienate local authorities and be looked upon as highly alternative and risky. More domestic documentation under local conditions should provide more security and make it more known.

A problem is finding someone who would have an interest in funding such research. The obvious answer seems to be that it should be in the state governments interests, given their focus on energy-efficiency and climate gas emission reductions, as part of a global effort in preventing climate change.

The lack of straw bale standards creates uncertainty about straw bale building. The complexity of the building process, vulnerability to moisture during building, and problems of getting enough dry and appropriately compressed straw bales in bad harvest years, are hurdles for straw bale building's diffusion.

Building a straw bale house takes longer time than building a ready-made house, and it is labour intensive. It is also difficult to set its resale value, because of the uncertainties attached to it, and a smaller market of buyers.

Some people's aversion to the alternative, fear of being regarded as outsiders in society, and their preconceptions about straw bale houses due to lack of knowledge, also make diffusion difficult.

Therefore, it is not surprising that my research shows that the people involved in straw bale building have some inclinations towards the "alternative". They were all in some form or another interested in sustainability issues, and took measures to lead a life of little environmental impact. Their main concern was to build a house free of chemicals and with good indoor climate, with great insulation properties, and with natural, qualitative and durable materials. The fact that so few of them mentioned money as an incentive to build with straw

goes to show that idealistic reasons must be more important to them. However, that does not mean that that is the case for the vast majority of house builders.

On the contrary, I believe that if measures were put in place to make the "green" choice available for the masses, as cheaply as any other alternative, the threshold to choose a straw bale house would probably be lower. This is why industrialization of straw bale buildings is important. We live in a society of mass fabrication; everything must be as rational and cost effective as possible in order to compete. If straw bale building were to enter this phase, it would be interesting indeed to see if the adoption curve started to form a steep S-shape as more and more people decided on straw as their building material of choice.

8. Further research

Even though most of the research regarding straw bale building is concerned with the technical aspects like for example insulation properties or moisture in walls, it is important to further investigate the properties of straw bale buildings to further decrease the uncertainty connected to this kind of building. Especially more documentation of the perceived advantageous indoor climate would be of importance for advocates of straw bale building.

It would also be beneficial to widen the scope of a diffusion study of straw bale building to include more countries, to see what experiences they have had regarding straw bale building and if there might be factors that make straw bale building more appropriate in specific countries under specific conditions.

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Appendix A – List of interviewees

Builders:

Tove and Anders Sanderhoff Sørensen, Skien, Telemark, Norway.
Tove and Anders live at a small farm. They are 34 and 32 years old and have to children age 4 and 6. Anders is a car panel beater, but works as a fireman. Tove is an IT-consultant in a firm in Prosgrunn and dreams of breading horses. Anders is fond of old and homemade things and rides a bike in his spare time. They describe themselves as active and outdoorsy people.

Ingrid and Fridrik Bertelsen, Nesoddtangen, Akershus, Norway.
Ingrid and Fridrik are 42 and 43 years old, they have four children aged 3-18. Fridrik works with conservation and restoration at the National Gallery and also in his private workshop. Ingrid is an apprentice to become a conservator. She has studied art and pedagogy.

Roar Lefsaker, Våle, Vestfold, Norway.
I do not have extensive information about Roar since his interview was conducted via e-mail.

Ole Busck, Skørping, Denmark.
Ole is a social professor at the Institute of planning at Aalborg University. He is a smith, educated at Helsingør shipyards. He works with issues like working environment, labor market and global environmental issues.

Experts:

Piet Jensen: Member of the board in NJH (Norsk Jord- og Hambyggeforening), carpenter and straw bale builder. Piet is Danish, but lives and builds straw bale houses in Norway. He has built straw bale houses since 1992.

Rolf Jacobsen: Architect (Gaia Tjøme) and author of "Straw as building material" (1999). Rolf estimates that he has in some manner been involved in the design and building of half of the Norwegian straw bale houses.

Caroline Meyer White: Engineer and straw bale builder. She has build several straw bale houses, among them some in Pakistan, where they are suitable due to their earthquake resistance qualities. Will write her PhD about prefabricated straw bale elements, whose production she will collaborate on with Steen Møller.

Steen Møller: Resource person in the Danish straw bale building community. Holds workshops and seminars. Has been an advisor in the building of many straw bale houses.

Appendix B – Interview guide

Questions related to E. M. Rogers "Diffusion of Innovations"

The Innovation

1. Relative advantage:

What are the advantages of straw bale building?

What are the disadvantages of straw bale building?

Follow up: Energy consumption, air quality, economic aspect, difficulties in building, finding experts or people with know-how?

2. Compatibility:

Why did you choose to build a straw bale house?

What are your thoughts and/or philosophy on environmental issues?

Follow up: Interest in ecology, environmental friendliness, economy, air quality, originality, what else do you do for the environment (car, organic food, sun-energy, rain water), is the house a part of a bigger "package"?

3. Complexity:

What obstacles did you encounter while building the house?

Follow up: Laws, structural or architectural, materials, knowledge, people, economy, societies feedback and opinions?

4. Trialability:

How did you become certain that it was "safe" to build a straw bale house?

Follow up: Who did you contact, experts, information gathering, did you visit a straw bale house?

5. Observability

Where did you find information about straw bale building?

Who did you speak to about straw bale building?

Follow up: Internet, books, people, what kind of institutions did you contact?

Communication Channels:

The question in the Observability section also provided information about communication channels.

Time:

When did you first hear about straw bale building?

When did you decide to build such a building?

Evaluation/Reinvention:

What has it been like to live in a straw bale house?

Would you do anything differently if you had the chance to build again?

Follow up: Structure, architecture, more environmental components (rain water, sun-energy), air quality, comfort, economy (how much do you recon you saved by building straw bale?)

Background information:

Age, occupation, previous experience with building, other interests.

Questions for the experts:

Why do you think most people do not build straw bale houses?

What characterises those who do?

What would in your opinion make more people build like this?

How is information about straw bale building spread?

Do you know of any differences between Norway and Denmark regarding straw bale building?